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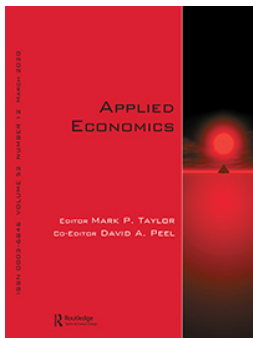
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Public Debt, Economic Growth and the Real Interest Rate: A Panel VAR Approach to EU and OECD Countries

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ABSTRACT

We investigate the causal relationship between public debt ratios and economic growth rates for 31 EU and OECD countries. We estimate a panel VAR model that incorporates the long-term real interest rate on government bonds as a vehicle to transmit shocks in both the public debt to GDP ratio and the economic growth rate. We find no causal link from public debt to growth, irrespective of the levels of the public debt ratio. Rather, we find a causal relationship from growth to public debt. In high-debt countries, the direct negative impact of growth on public debt is enhanced by an increase in the long-term real interest rate, which in its turn decreases interest-sensitive demand and leads to a further increase in the public debt ratio.

KEYWORDS

Public debt; economic growth; interest rate; panel VAR; Granger causality

JEL CLASSIFICATION

E62; H62

1. Introduction

Since the 2008/9 global financial crisis, many countries applied economic policies based on a mix of loose monetary policy and some form of fiscal austerity. In the European Union this policy mix has on the one hand prevented the banking system to collapse, but on the other also led to negative economic growth rates and increasing unemployment rates, especially in Southern European countries. At the basis of the desire for austerity in for instance the Eurozone countries is the concern for stability of the monetary union, as laid down in the Maastricht Treaty. In order to be a Eurozone-member a country needs to fulfil fiscal rules which set margins for both the primary public fiscal deficit (from now in short labelled ‘deficit’) and the public debt to GDP ratio (hereafter debt ratio). At the core of this set of fiscal rules is the notion that too large deficits and/or debt ratios will lead to crowding out of real expenditures and so will hurt economic growth. The main mechanism of crowding out runs via the real interest rate: larger debt ratios will push up real interest rates, leading to lower real expenditures and so lower economic growth. Also in non-Eurozone countries similar concerns have been put forward, but to a lesser extent. It remains an

empirical issue whether the negative impact of the debt ratio on economic growth is relevant and, most likely are the social costs of pulling the ‘wrong conclusion’ high. Suppose that causality does not run from debt to growth but the other way round? In the latter case a financial crisis, that gave a negative shock to growth and has increased the risk premium on the real interest rate, will possibly lead to more intense debt problems without even having the likely positive impact of an increase in net government expenditures. And if this negative interaction is more relevant to countries with relatively high debt ratios, fiscal austerity might not be an ideal recipe for economic recovery. Moreover, countries with relative low debt ratios, like the countries in Northern Europe, should exploit fiscal expansion.

The seminal work of Reinhart and Rogoff (2010) finds that public debt overhang has a negative impact on economic growth when the debt ratio is high. Their study has sparked an empirical investigation into the relationship between debt and growth. A number of studies has examined non-linear relationships between the two variables, where there exists a threshold beyond which public debt has a negative impact on economic growth. Many studies have found evidence in favour of

a nonlinear negative relationship, but their results are sensitive to time dimension, country coverage, data frequency and econometric methods applied.¹ Moreover, to the best of our knowledge, not a single study convincingly demonstrates a causal link from debt to growth with a transmission mechanism explicitly taken into consideration.²

We employ a Vector AutoRegression (VAR) to analyse dynamic interrelations among the variables of interest. We test the presence of Granger causality between economic growth, public debt and the long-term real interest rate on government bonds. High levels of debt cast doubt on the likelihood of full repayment of debt and might lead to higher risk premia and associated higher long-term real interest rates. This has in turn a negative impact on economic growth via a decline in interest-sensitive expenditures.³

Specifically, we estimate a panel VAR model developed by Holtz-Eakin, Newey, and Rosen (1988). Our model describes the dynamic relation among public debt, economic growth and the long-term real interest rate for data of 31 EU and OECD countries from 1995 to 2013. Interestingly, our sample years cover the recent European sovereign debt and financial crisis. We find no causal link from debt to real growth, irrespective of the levels of the debt ratio. Rather, we find a causal relation from the growth rate to the level of debt for countries with both high levels of the debt ratio and those with low levels of debt to GDP. This might not be considered as a surprise, because a real decrease in GDP might lead to a nominal decrease in GDP and so automatically increase the debt to nominal GDP-level. But there is more going on. Quantitatively, the impact of economic growth on public debt is larger in countries with high levels of debt. This is because the negative effects of low economic growth on public debt are amplified through the real interest rate channel. A negative shock to economic growth initially raises the levels of public debt via an increase in government expenditures,

hoping to boost the economy, and a decrease in tax revenues. In addition to this direct impact of growth on debt, the slowdown in growth raises the long-term real interest rate, possibly due to a lower inflation rate, which in turn reduces growth by decreasing interest-sensitive spendings and leads to a further increase in debt. A rise in the long-term real interest rate also increases interest payments on debt and thus further raises the level of debt. As is well-known the difference between the real growth rate and the real interest rate is a crucial parameter for sustainability of public debt. We find that a one-standard-deviation decrease in the real GDP growth rate raises the ratio of public debt to GDP by 2.10 percent points for high-debt countries but only 0.79 percent points for low-debt countries.

The remainder of the paper is organized as follows. In Section 2 we provide a brief survey of the recent literature on the relationship between public debt and economic growth and present our hypothesis on how public debt affects economic growth. We describe our dataset and present descriptive statistics in Section 3. Section 4 contains our empirical results. The last section presents our conclusions.

II. Literature on the magnitude of and channels through which public debt affects economic growth

Reinhart and Rogoff's (2010) seminal paper finds that public debt overhang has a negative impact on economic growth at high debt levels, often at a debt ratio above 90 percent. Countries with debt ratios above 90 percent have mean growth rates that are almost 4 percentage points lower than in lower debt countries. Their finding is originally based on descriptive statistics of historical episodes, which has stimulated a number of rigorous econometric studies.

Panizza and Presbitero (2013) survey the recent literature on the links between debt and economic growth and state that the relationship between debt

¹Égert (2015) finds that nonlinear effects change over time, across countries and economic conditions. Kourtellis, Stengos, and Tan (2013) find that higher public debt results in lower growth for countries in low-democracy regimes. Panizza and Presbitero (2014) show that once endogeneity is corrected for, the link between public debt and growth disappears. They instrument public debt with the valuation effects brought about by the interaction between currency debt and movements in the exchange rate. See Panizza and Presbitero (2013) for a survey of empirical studies dealing with the relationship between public debt and economic growth.

²Islam and Hasan (2007) examine the effects of government debt on interest rate, capital formation and output based on a Vector Error Correction Model (VECM). However, their study is confined to post-war USA data.

³The channel through which high public debt adversely affects economic growth is stated in Baldacci and Kumar (2010) and Reinhart, Reinhart, and Rogoff (2012).

and growth is characterized by large cross-country heterogeneity and may vary over time within countries.

There are many studies which find empirical support of a negative nonlinear relationship between debt and growth. For example, Kumar and Woo (2015) confirm that only high levels of debt (ratios above 90 percent of GDP) exert a significant negative impact on growth. They find that a 10 percentage-point increase in the initial debt ratio is associated with a slowdown of the real per capita GDP growth rate of 0.2 percentage-points per year. Cecchetti, Mohanty, and Zampolli (2011) also find, in various specifications of growth regressions, that the threshold beyond which government debt has a negative impact on growth is approximately 85% of GDP. They find that a 10 percentage-point increase in the debt ratio reduces real growth by more than one tenth of 1 percentage-point. Checherita-Westphal and Rother (2012) find a nonlinear impact of debt on long-term growth with a turning point at approximately 90–100% of debt to GDP. Baum, Checherita-Westphal, and Rother (2013) suggest that the short-run impact of debt on growth is positive and highly statistically significant but falls to about zero and loses significance when the ratio of debt to GDP reaches approximately 67%. For high debt to GDP ratios (above 95%), additional debt has a negative impact on economic activity. They find that a 1 percentage-point increase in the debt ratio reduces real growth by 0.06 percent point. Afonso and Jalles (2013) find that the threshold value of the debt ratio is 58% for the Euro area and a higher 79% for emerging countries.

Some studies emphasize that the negative relationship between public debt and growth depends on country-specific factors and institutions like the degree of financial deepening and variation of political system and the sample period chosen. Kourtellis, Stengos, and Tan (2013) find that higher public debt results in lower growth only for countries with poor democracy regimes. Dreger and Reimers (2013) show that the negative impact of public debt is limited to the euro area and periods of non-sustainable public debt. They further note that the negative debt effect diminishes for industrial countries and that debt exerts a positive impact on economic growth provided debt is sustainable. Égert (2015) finds some evidence in favour of a negative

nonlinear relationship between debt and growth but again warns that results are very sensitive to the time period and set of countries, data frequency and assumptions on the minimum number of observations required in each nonlinear regime. He reports that when non-linearity is detected, the negative nonlinear effect starts at much lower levels of public debt (between 20% and 60% of GDP) compared to linear models. Panizza and Prebistero (2014) find that a negative link between debt and growth disappears once they correct for endogeneity by accounting for movements in the exchange rate. Some studies take explicit account of cross-country heterogeneity. Eberhardt and Presbitero (2015) model the debt-growth relationship as heterogeneous across countries and find some support for a negative relationship between debt and long-run growth across countries, but find no evidence for an identical debt threshold within countries. Using a dynamic heterogeneous panel data model, Chudik et al. (2013) find that a permanent increase in debt has a negative impact on economic growth in the long run, but if the increase is temporary, then there are no long-run growth effects. Using the same model, Chudik et al. (2017) find no evidence for a universally applicable threshold effect in the relationship between debt and growth.

Previous empirical studies have mainly focused on detecting a negative relationship between public debt and economic growth, but there are no studies aimed at identifying the channels through which public debt affects economic growth. One channel through which public debt is transmitted to growth is via the long-term interest rate. Reinhart, Reinhart, and Rogoff (2012) argue that the interest rate channel works as follows: sufficiently high levels of public debt call into question whether debt will be repaid in full, thus leading to a higher risk premium and an associated higher long-term real interest rate, which in turn lowers economic growth by decreasing interest-sensitive expenditures on investment and durables. Baldacci and Kumar (2010) confirm this conjecture and find that debt leads to a significant increase in long-term interest rates, with the precise magnitude depending on initial fiscal, institutional and other structural conditions. Baum, Checherita-Westphal, and Rother

(2013) also suggest a nonlinear relationship between public debt and the long-term interest rate and find that additional public debt increases the long-term interest rate above a threshold debt to GDP ratio of approximately 73.8%. However, Checherita-Westphal and Rother (2012) report that debt levels are not statistically significant in determining long-term interest rates in either linear or quadratic forms.⁴ Reinhart and Rogoff (2010) also provide evidence that countries with a public debt overhang do not always experience a sharp rise in real interest rates. Nonetheless, even if a significant positive impact of public debt on the long-term interest rate is detected, it does not necessarily imply that public debt has an adverse impact on economic growth. Rather, we have to show that a higher long-term interest rate decreases growth, which is unquestionably theoretically correct, but is by no means empirically self-evident. Therefore, we have to analyse the causal relations among public debt, economic growth and the long-term real interest rate.

A panel VAR model is the ideal econometric tool to analyse dynamic interactions among public debt ratio, real growth and the real long-term interest rate. There have been panel VAR-studies that examine the causal link between public debt and economic growth. Ferreira (2009) estimates a panel VAR model of the real GDP growth rate and public debt, measured by current primary surplus/GDP ratio and gross government debt/GDP ratio and finds bi-directional Granger causality between economic growth and sovereign debt. Lof and Malinen (2014) estimate a panel VAR model of real growth and the growth rate of total gross government debt and conclude that the negative correlation between sovereign debt and economic growth is primarily driven by the impact of economic growth on sovereign debt rather than vice versa. Puente-Ajovín and Sanso-Navarro (2015) investigate the presence of Granger causality between public debt and economic growth in 16 OECD countries and find

that, with the exception of a few countries, there is a causal link from economic growth to public debt, not from public debt to growth. Gómez-Puig and Sosvilla-Rivero (2015) conduct Granger causality test between growth and debt for individual 11 Economic and Monetary Union (EMU) countries and find evidence of a negative Granger-causality between changes in sovereign debt and growth in some of the countries. Donayre and Taivan (2017) examine the direction of causality between public debt and real economic growth in a sample of 20 OECD countries for the years 1970–2010 and find that modern welfare states tend to face low real growth following increases in public debt, but more traditional welfare states typically exhibit either causality from low growth to debt accumulation or a bidirectional causality.

Table 1 summarizes the previous contributions, based on VAR-models, to the causality between debt and growth. Previous panel VAR studies only analyse the bi-variate relationship between debt and growth. In this paper we shed light on the role of long-term interest rate in transmitting shocks in debt onto growth and vice versa by examining a tri-variate panel VAR model of public debt, economic growth and the long-term real interest rate.

III. Data

Our sample includes 27 EU countries and 4 OECD countries (Australia, Canada, Japan and the United States).⁵ The sample period covers the years 1995 to 2013. This selection of countries and range of sample years offsets some of the critiques that previous studies incurred. The 31 countries have a stable democracy and share common goals of transparency in both fiscal and monetary policy and have installed other essential institutions. The sample years include economic variation, with economic prosperity (the 1990s) on the one hand, and the years of the worldwide financial crisis (2007–2013) on the other, but do not contain shifts in structural views on the role of government debt. Our

⁴Checherita-Westphal and Rother (2012) find that the variables through which public debt has a nonlinear impact on economic growth are private savings, public investment and total factor productivity.

⁵Croatia is not included in our set.

Table 1. Previous studies on the causality between public debt and economic growth based on VAR models.

authors	countries	time periods	methodology	main findings
Ferreira (2009)	20 OECD countries	1988–2001	Granger causality test between real GDP growth and public debt (primary surplus/GDP ratio and gross government debt/GDP ratio) based on panel VAR	There is bi-directional Granger causality between economic growth and sovereign debt.
Lof and Malinen (2014)	20 developed countries	1957–2008	two-variate (growth rates of real GDP per capita and the growth rate of total gross government debt per capita) panel VAR	They find no evidence for a robust effect of debt on growth, even for higher levels of debt. They find a significant negative reverse effect of growth on debt.
Puente-Ajovín and Sanso-Navarro (2015)	16 OECD countries	1980–2009	panel Granger causality test between real GDP growth and debt-to-GDP ratio	Their studies do not support the idea that government debt Granger causes growth. There is stronger evidence for causality from non-financial private debt to growth.
Gómez-Puig and Sosvilla-Rivero (2015)	11 EMU countries	1980–2013	Granger causality test between real GDP growth and debt-to-GDP ratio for individual 11 EMU countries	When they analyse Granger-causality after endogenously detecting a breakpoint, they find evidence of negative Granger-causality between changes in sovereign debt and growth in some of the countries studied between the break date and the end of the sample period in 2013.
Donayre and Taivan (2017)	20 OECD countries	1970–2009	Granger causality test between real GDP growth and debt-to-GDP ratio for individual 20 OECD countries	While modern welfare states tend to face low real growth following increases in the debt-to-GDP ratio, more traditional welfare states and those with larger governments typically exhibit either causality from low growth to debt accumulation or bidirectional causality.

sample period is also suitable for analysing the relationship between public debt and economic growth during the recent European sovereign debt and financial crisis. Specifically, in the Greek crisis of 2015, one of the topics of discussion between the Greek government and the ‘Trojka’ (the European Commission, the European Central Bank, and the International Monetary Fund) was the excessive burden of government debt – and additional foreign debt – on the real GDP growth rate. Similar discussions were held during the Irish, Portuguese, and Spanish rescue plans in the years 2011–2013. We include three basic variables: the real GDP growth rate, the ratio of public debt to GDP and the long-term real interest rates. The real GDP growth rate is calculated as the log difference of real GDP in terms of the 2010 national currency market price. The ratio of public debt to GDP is defined as the gross debt of the general government divided by nominal GDP. The long-term real interest rate is calculated as the nominal long-term (in most cases 10 year) government bonds minus the inflation rate in terms of GDP deflator. The data sources are the Eurostat and OECD databases.

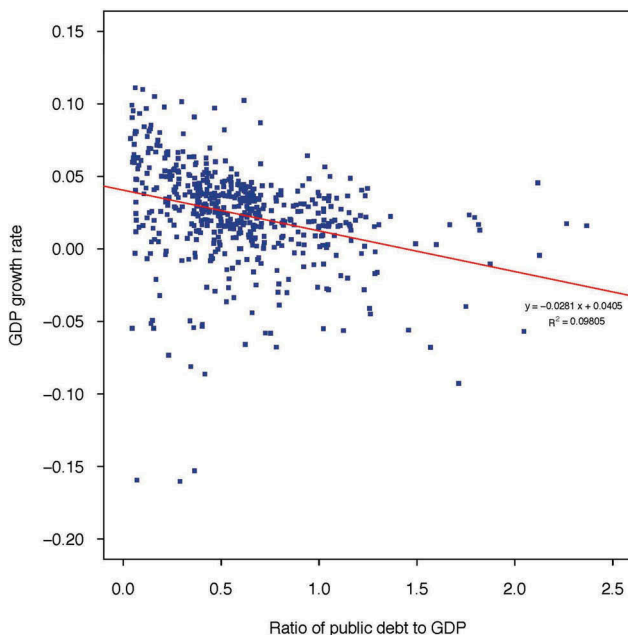
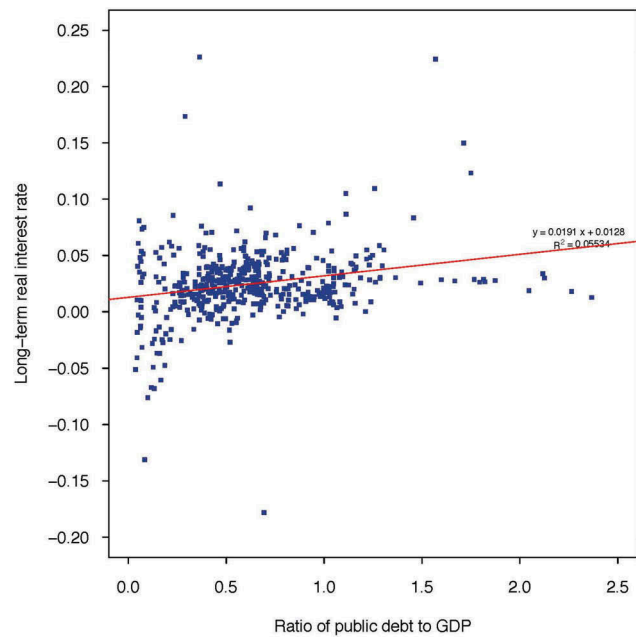
Table 2 presents the means of the real GDP growth rate, the public debt ratio and the long-term real interest rate for each country. The debt ratio varies more widely across countries than the GDP growth rate or the long-term interest rate. The debt ratio exceeds 100% in five countries: Japan, Greece, Italy, Canada and Belgium, while it is less than 20% in Estonia (6.14%) and Luxembourg (10.81%). The real GDP growth rate ranges from 0.5% (Italy) to 4.41% (Estonia), while the long-term real interest rate ranges from –0.09% (Romania) to 5.13% (Greece).

Figure 1 exhibits a scatter diagram presenting the debt ratio and the real GDP growth rate. We observe a negative correlation between the debt ratio and the GDP growth rate. The correlation coefficient is –0.31, and the null hypothesis of no correlation is decisively rejected at the 1% significance level. Figure 2 exhibits a scatter diagram presenting the debt ratio and the long-term real interest rate. We observe a positive correlation between the debt ratio and the long-term real interest rate. The correlation coefficient for the whole sample is 0.24 and the null hypothesis of no correlation is also rejected at the 1% significance level. Note that the correlation coefficient gives no information about the direction of the

Table 2. Means of variables by country (%).

		Public debt ratio	GDP growth rate	Long-term real interest rate
1	Australia	42.49	3.21	2.70
2	Austria	70.18	1.88	2.75
3	Belgium	105.71	1.74	2.57
4	Bulgaria	39.24	2.23	-0.07
5	Canada	105.84	2.52	2.35
6	Cyprus	60.07	2.28	2.96
7	Czech Republic	26.47	2.25	2.63
8	Denmark	47.96	1.21	2.10
9	Estonia	6.14	4.41	2.24
10	Finland	44.93	2.30	2.51
11	France	68.24	1.61	2.75
12	Germany	65.54	1.25	3.00
13	Greece	112.14	0.87	5.13
14	Hungary	67.19	2.03	2.62
15	Ireland	57.36	4.05	2.78
16	Italy	109.56	0.50	2.81
17	Japan	166.07	0.81	2.57
18	Latvia	20.02	4.30	0.68
19	Lithuania	25.31	4.39	2.47
20	Luxembourg	10.81	3.36	1.22
21	Malta	61.33	2.12	2.15
22	Netherlands	57.05	1.82	2.11
23	Poland	45.79	4.00	3.54
24	Portugal	72.61	1.10	3.17
25	Romania	21.04	2.56	-0.09
26	Slovak Republic	38.87	3.83	2.19
27	Slovenia	30.58	2.45	2.57
28	Spain	57.16	2.11	2.44
29	Sweden	49.49	2.33	2.75
30	United Kingdom	52.34	2.03	2.30
31	United States	85.50	2.41	2.42

Data source: EuroStat, OECD Database.

**Figure 1.** Scatter diagram of the public debt ratio and the GDP growth rate.**Figure 2.** Scatter diagram of the public debt ratio and the long-term real interest rate.

causal links among the variables, thus, we estimate a panel VAR model to analyse the causal relationships in the next section.

IV. Estimation results

We estimate a panel VAR model using data from 31 countries over the years 1995 to 2013. In applying the panel VAR model we control for individual heterogeneity using fixed effects. The mean-differencing procedure commonly used in panel data models yields biased estimates due to presence of lagged dependent variables among the explanatory variables. Therefore, following Arellano and Bover (1995), we use forward-mean differencing, commonly known as the Helmert procedure, to eliminate fixed effects. The virtue of this procedure is that we can use untransformed lagged regressors as instruments. We use the variables lagged by one and two years. The model is estimated by System Generalized Methods of Moments (SGMM).⁶

The optimal lag order is chosen using the three model selection criteria for SGMM models as proposed by Andrew and Lu (2001). The three

⁶We use the Stata program originally developed by Love and Zicchino (2006) and extended by Abrigo and Love (2015).

criteria are analogous to the Akaike information criteria (AIC), the Bayesian information criteria (BIC) and the Hannan-Quinn information criteria (HQIC). We finally choose the lag length to be equal to one. In estimating a panel VAR model, we include time fixed effects as exogenous variables to account for aggregate macroeconomic shocks.

Bi-variate case

First, we estimate a basic two-variate panel VAR model of the debt-to-GDP ratio and the real GDP growth rate for the whole sample (Case 1). The stability condition of the panel VAR model and the Hansen test statistics of overidentifying restrictions are satisfied for all cases.⁷ Table 3 shows the Wald statistics to test for Granger causality. We find Granger causality from real GDP growth to public debt but not vice versa. Figure 3 depicts the impulse responses to a one standard deviation shock to the real GDP growth rate and the debt ratio together with the associated 90 percent confidence intervals.⁸ The ordering of the variables is first the debt ratio and second the GDP growth rate. The debt ratio is decreased by 0.87 percentage-points two years after a positive unexpected shock to the real GDP growth rate and the negative effect persists for even ten years after the shock. In contrast, the real GDP

growth rate falls by 0.5 percent points immediately after the public debt ratio increases unexpectedly, but the negative effect lasts only two years.⁹

Some might argue that the failure to detect the impact of public debt on economic growth is due to likely misspecification of the model. Many studies (see Section II) find a threshold above which public debt exerts a negative impact on economic growth and below which public debt has no impact. To account for the differential effects of public debt on economic growth, we split the 31 sample countries above and below the sample mean of the debt ratio: a high-public-debt group (16 countries) and a low-public-debt group (15 countries).¹⁰ The bi-variate panel VAR model is re-estimated separately for the high-public-debt group (Case 2) and the low-public-debt group (Case 3). Table 3 shows that there is no causal link from public debt to economic growth for the high-public-debt group, however, we do observe a weak causal link from the public debt to GDP ratio to economic growth for the low-public-debt group. We observe Granger causality from economic growth to public debt for both the high- and low-public-debt groups. Figures 4 and 5 depict the impulse responses for both groups. The relative impact of economic growth on public debt is larger for the high-debt group. The debt ratio is lowered by 1.73 percentage points three years after a positive one standard deviation unexpected shock to the GDP growth rate for the high-debt group, while the equivalent figure is 0.75 percentage points for the low-debt group.¹¹ Note that the relative size of the shocks differs between the two experiments, so we need to denote the results in relative terms. The impact of the debt to GDP ratio on economic growth is larger for the low-debt group. For the low-debt (high-debt) group, the GDP growth rate is lowered by 0.83 (0.30) percentage-points immediately after a one standard-deviation positive unexpected shock to the debt ratio.¹² So, from the bi-variate models we

Table 3. Test statistics of panel VAR model: bi-variate case.

	Excluded variables	Granger causality Wald statistics
Case 1	GDP growth equation: Debt to GDP ratio	0.034 (0.854)
	Debt to GDP ratio equation: GDP growth rate	9.886 (0.002)
Case 2 High-debt countries	GDP growth equation: Debt to GDP ratio	0.038 (0.846)
	Debt to GDP ratio equation: GDP growth rate	4.018 (0.045)
Case 3 Low-debt countries	GDP growth equation: Debt to GDP ratio	3.053 (0.081)
	Debt to GDP ratio equation: GDP growth rate	9.546 (0.002)

Note: The values in parentheses are *p*-values.

⁷Note that a VAR model is stable if all moduli of the eigenvalue of the estimated models are strictly less than unity. See Hamilton (1994, 260–261).

⁸Confidence intervals are estimated from 2,000 Monte Carlo simulations of the estimated panel VAR model.

⁹A one standard deviation shock to the real GDP growth rate and the debt to GDP ratio is 1.93 and 3.75 percentage-points, respectively.

¹⁰The threshold level of public debt ratio is 57.05%. The countries in the high-public-debt group are Belgium, Germany, Ireland, Greece, Spain, France, Italy, Cyprus, Hungary, Malta, the Netherlands, Austria, Portugal, Canada, Japan and the United States. Those in the low-public-debt group are Australia, Bulgaria, Czech Republic, Denmark, Estonia, Latvia, Lithuania, Luxembourg, Poland, Romania, Slovak Republic, Slovenia, Finland, Sweden and United Kingdom.

¹¹A one standard deviation shock to the real GDP growth rate is 1.27 and 2.23 percentage-points for the high-debt and low-debt groups, respectively.

¹²A one standard deviation shock to the debt to GDP ratio is 4.02 and 2.61 percentage-points for the high-debt and low-debt groups, respectively.

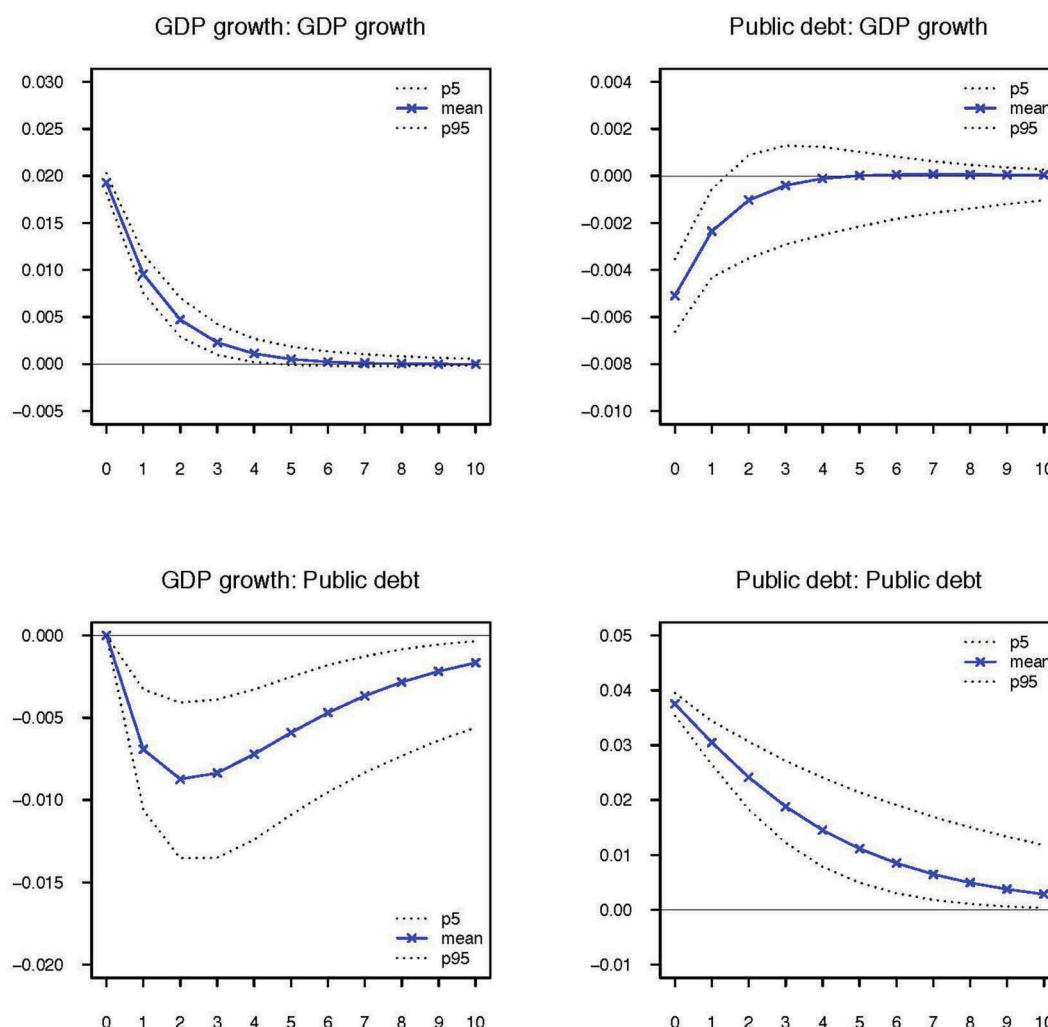


Figure 3. Impulse responses: basic bi-variate case.
Notes: impulse variable: response variable

conclude that there is an impact of economic growth on public debt and that the other way round only low-debt countries observe a negative impact of higher public debt levels. The latter might be considered counterintuitive, but needs further elaboration: this is done in the next section, where we incorporate the real interest rate channel.

Tri-variate case

Next we estimate a tri-variate panel VAR model of the debt ratio, the real GDP growth rate and the long-term real interest rate for the whole sample (Case 4). Table 4 shows the relevant test statistics of the estimated tri-variate panel VAR model, which provide support for the validity.

Even if the model is extended to incorporate the possible impact of public debt on economic growth via the long-term real interest rate, we cannot detect a causal link from public debt to economic growth. There is no direct impact of the debt ratio on the real GDP growth rate. Moreover, we cannot find indirect effects of public debt on economic growth, because we do not detect Granger causality either from the debt to GDP ratio to the long-term real interest rate or from the long-term real interest rate to the GDP growth rate.

In contrast, we still find a causal link from economic growth to debt. Additionally, we do find a causal link from economic growth to the long-term real interest rate. A rise in the GDP growth rate leads to a fall in the long-term interest rate, most likely by way of an increase in the expected inflation rate.

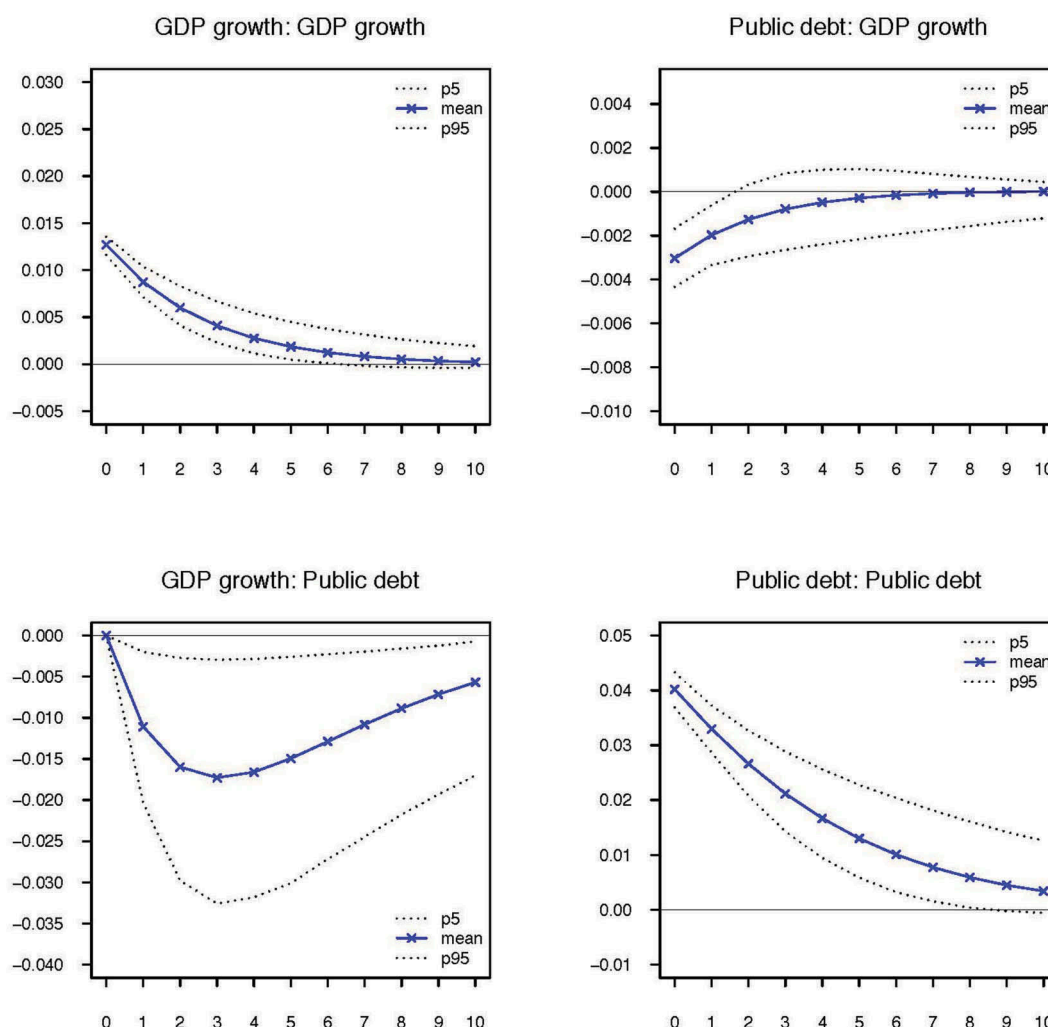


Figure 4. Impulse responses: bi-variate case for high-debt countries.
Notes: impulse variable: response variable

Figure 6 depicts the impulse responses for the tri-variate case. The ordering of the variables is the debt ratio, the long-term real interest rate and the real GDP growth rate.¹³ The debt ratio is lowered by 0.72 percent points three years after a positive unexpected shock to the GDP growth rate and the negative effect on the debt ratio persists for ten years. The real GDP growth rate falls by 0.37 percentage-points immediately after the debt ratio increases unexpectedly, but the negative effect is temporary and lasts only two years. The impact of economic growth on public debt when the interest rate is endogenized is quantitatively similar to the two-variate case

(Case 1). The long-term interest rate decreases by 0.56 percentage-points one year after a positive unexpected shock to the real GDP growth rate.¹⁴

We continue by separating the sample countries again in a high- and low-public debt group and estimate a tri-variate panel VAR model separately for the high-public-debt group (Case 5) and low-public-debt group (Case 6). We observe several common causal links among the variables for both groups (see Table 4). First, there is a direct causal link from economic growth to public debt. Secondly, there is no causal link from public debt to

¹³The tri-variate VAR model is also estimated by reordering the variables as follows: the real GDP growth rate, the debt to GDP ratio and the long-term real interest rate. The estimated results remain essentially unaltered.

¹⁴A one standard deviation shock to the real GDP growth rate and the debt-to-GDP ratio is 1.69 and 3.81 percentage points, respectively.

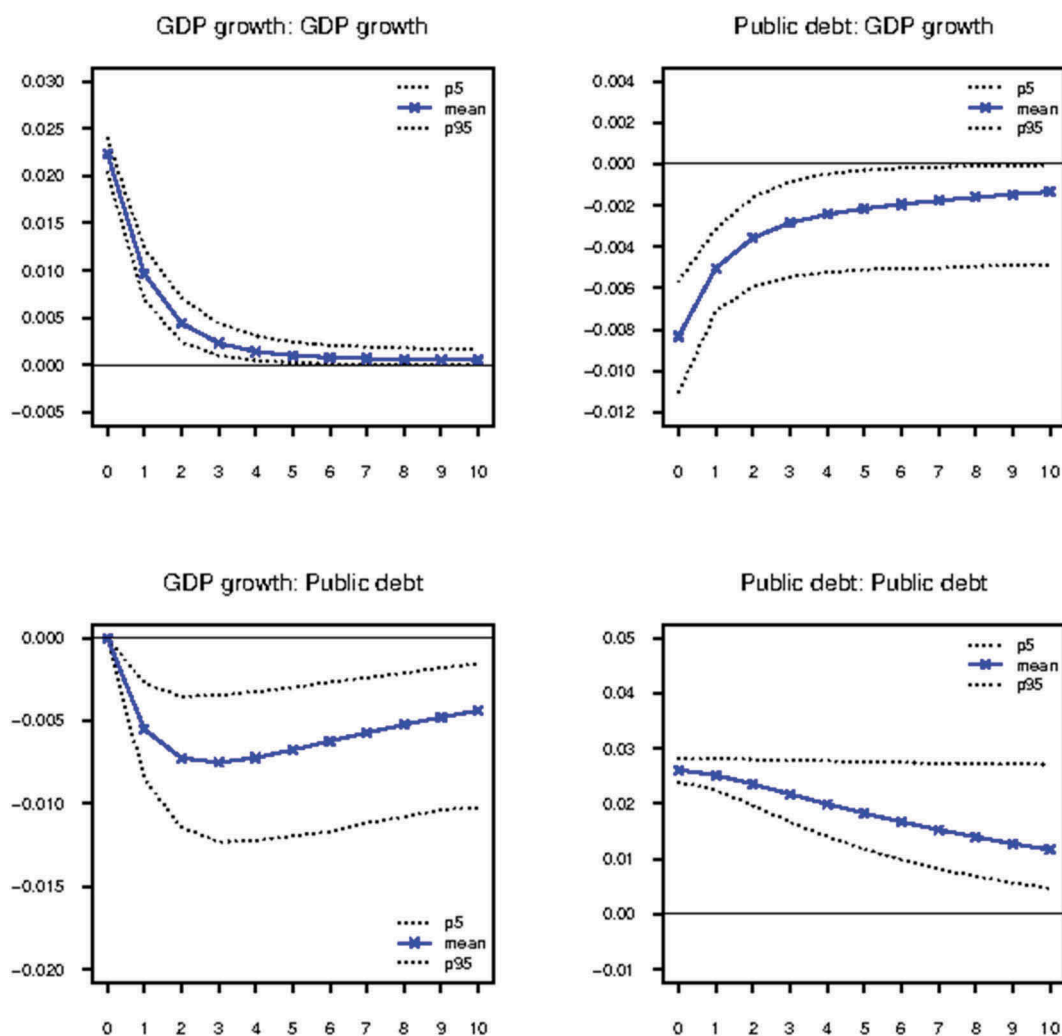


Figure 5. Impulse responses: bi-variate case for low-debt countries.
Notes: impulse variable: response variable

economic growth, irrespective of the levels of debt. This finding illustrates that the inclusion of the real interest rate channel is important and offsets the initial – surprising – result in [section 4.1](#), that public debt did have an impact on growth for low-debt countries. Thirdly, an increase in the real GDP growth rate lowers the long-term real interest rate. Moreover, we uncover additional causal links among the variables for the high-public-debt group. One of these additional links is a causal link from the long-term real interest rate to economic growth. This implies that economic activities are sensitive to a change in the long-term real interest rate for the high-public-debt group. We also find a causal link from the long-term real interest rate to the debt ratio. A rise in the

long-term real interest rate increases interest payments on public debt and thus raises the debt ratio.

We now summarize the channel through which a negative unexpected shock to the real GDP growth rate is transmitted to an increase in public debt. For low-debt countries, we observe only the direct link from the real growth rate to public debt. That is to say, a negative shock to the real growth rate raises the levels of public debt via a likely standard increase in government expenditure and a decrease in tax revenues. For high-debt countries, an initial negative impact of economic growth on public debt is further amplified through the interest rate channel. In other words, a slowdown in the growth rate raises the long-term real interest rate,

Table 4. Various test statistics of panel VAR model: tri-variate case.

	Excluded variables	Granger causality Wald statistics
Case 4	GDP growth equation:	
	Debt-to-GDP ratio	0.027 (0.869)
	Long-term interest rate	1.697 (0.193)
	Debt-to-GDP ratio equation:	
	GDP growth rate	3.548 (0.060)
	Long-term interest rate	1.958 (0.162)
	Long-term interest rate equation:	
	GDP growth rate	13.655 (0.000)
	Debt-to-GDP interest rate	0.073 (0.788)
Case 5 High debt countries	GDP growth equation:	
	Debt-to-GDP ratio	1.885 (0.170)
	Long-term interest rate	10.013 (0.002)
	Debt-to-GDP ratio equation:	
	GDP growth rate	12.483 (0.000)
	Long-term interest rate	6.316 (0.012)
	Long-term interest rate equation:	
	GDP growth rate	6.687 (0.010)
	Debt-to-GDP interest rate	0.020 (0.887)
Case 6 Low debt countries	GDP growth equation:	
	Debt-to-GDP ratio	1.029 (0.310)
	Long-term interest rate	5.629 (0.018)
	Debt-to-GDP ratio equation:	
	GDP growth rate	8.955 (0.003)
	Long-term interest rate	2.437 (0.119)
	Long-term interest rate equation:	
	GDP growth rate	8.219 (0.004)
	Debt-to-GDP interest rate	1.452 (0.228)
Case 7 High debt countries (long-term interest rate exogenous)	GDP growth equation:	
	Debt-to-GDP ratio	0.492 (0.483)
	Debt-to-GDP ratio equation:	
	GDP growth rate	2.582 (0.108)

Notes: The values in parentheses are *p*-values.

possibly due to a lower inflation rate, which in turn reduces the real growth rate by decreasing interest-sensitive demand and leads to a further increase in public debt. A rise in the long-term real interest rate also increases interest payments on public debt and further raises the level of public debt.

Figure 7 schematically compares the transmission mechanisms from economic growth to public debt between high-debt countries and low-debt countries. Quantitatively seen, the impact of the real growth rate on public debt is much larger for high-debt countries. Figures 8 and 9 show the impulse responses for high- and low-debt countries, respectively. The debt ratio is lowered by 0.79 percentage-points two years after a positive shock to GDP for low-debt countries, while the debt ratio is lowered by 2.10 percent points five years after a positive shock to the GDP growth rate for high-debt

countries (note again that we report the relative effects).¹⁵ In high-debt countries, the impact of economic growth on the debt ratio is persistent, and the debt ratio is still 1.63 percentage-points lower ten years after the positive shock to economic growth. In high-debt countries, the debt ratio increases by 3.67 percentage-points six years after a positive shock to the long-term interest rate.

Finally, we make a quantitative evaluation of the extent to which the long-term interest rate amplifies the shock to the GDP growth rate by comparing the pattern of the impulse responses under an endogenous interest rate with the pattern of responses under an exogenous interest rate (Case 7) for high-debt countries. Figure 10 shows the impulse responses when the interest rate is assumed to be exogenous. The debt ratio decreases only by 1.33 percent points three years after an

¹⁵A one standard deviation shock to the real GDP growth rate is 1.21 and 1.97 percentage-points for the high-debt and low-debt groups, respectively.

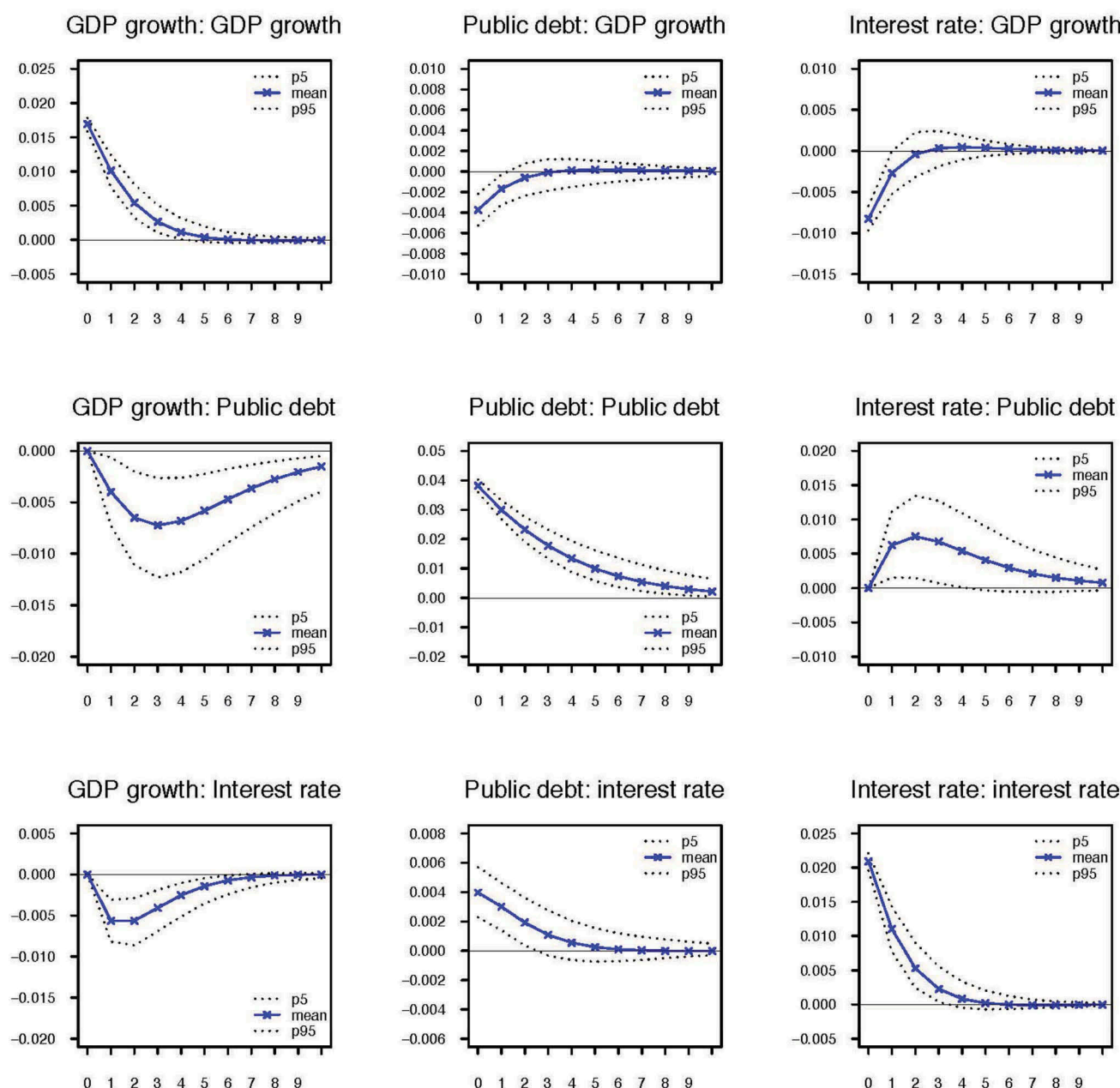


Figure 6. Impulse responses: basic tri-variate case.
Notes: impulse variable: response variable

unexpected shock to the GDP growth rate, which is 0.77 percent points smaller than the case of an endogenous interest rate.¹⁶

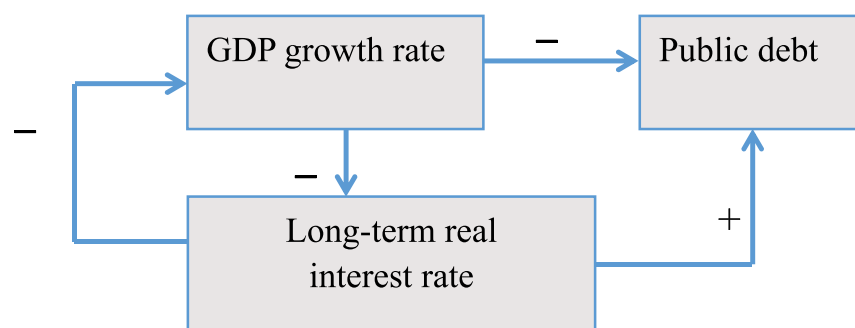
Case of EMU countries

As is discussed in Section 2, the negative relationship between public debt and economic growth is affected by cross-country heterogeneity. To control

for country heterogeneity, we estimate the VAR model for the original 11 Economic and Monetary Union (EMU) member countries. The sample period is from 1999 to 2012. The virtue of choosing only the original member states participated in EMU is that they are relatively homogeneous in terms of monetary policy since they conduct common monetary policy. Table 5 shows the Wald statistics to test for Granger causality for

¹⁶A one standard deviation shock to the real GDP growth rate is 1.25 percentage-points.

1) High-debt countries



2) Low-debt countries

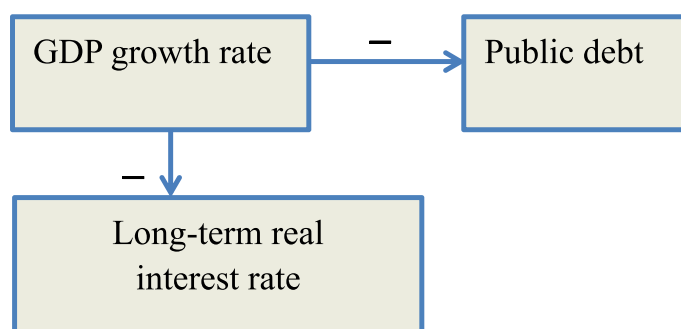


Figure 7. Causal relationship among the public debt, economic growth and interest rate: schematic illustration.

the bi-variate and tri-variate cases. We find Granger causality from the real GDP growth rate to the public debt ratio but not vice versa for both the bi-variate and tri-variate case. Figure 11 depicts the impulse responses for the tri-variate case. The debt ratio is decreased by 2.57 percent points three years after a positive unexpected shock to the GDP growth rate and the negative effect on the debt ratio persists for ten years. In contrast, the real GDP growth rate falls only by 0.27 percent points immediately after the debt ratio rises unexpectedly and the negative effect disappears after two years.¹⁷ Our results for the EMU-countries show that Granger causality from the real GDP growth rate to the debt ratio is robust.

V. Concluding remarks

In this paper we find a causal link from economic growth to public debt by estimating a panel VAR model that accounts for the interest channel through

which a shock to economic growth is transmitted to the public debt and vice versa for EU and OECD countries from 1995–2013. However, we fail to find a reverse causality from public debt to economic growth. Our findings remain valid if we split the sample countries into a high-public-debt group and a low-public-debt group. Our findings show that the long-term real interest rate plays a vital role in transmitting a shock in economic growth to public debt for high-public-debt countries.

Although we could not detect a causal link from public debt to economic growth, even for high-debt countries, public debt might be accumulated for many years once a negative shock hits the GDP growth rate. This accumulation is due to a rise in the real interest rate, which in turn decreases interest-sensitive demand and further increases public debt. Rapid accumulation of public debt might start to adversely affect economic growth if financial markets perceive the level of public debt as

¹⁷A one standard deviation shock to the real GDP growth rate and the debt-to-GDP ratio is 1.15 and 3.09 percentage-points, respectively.

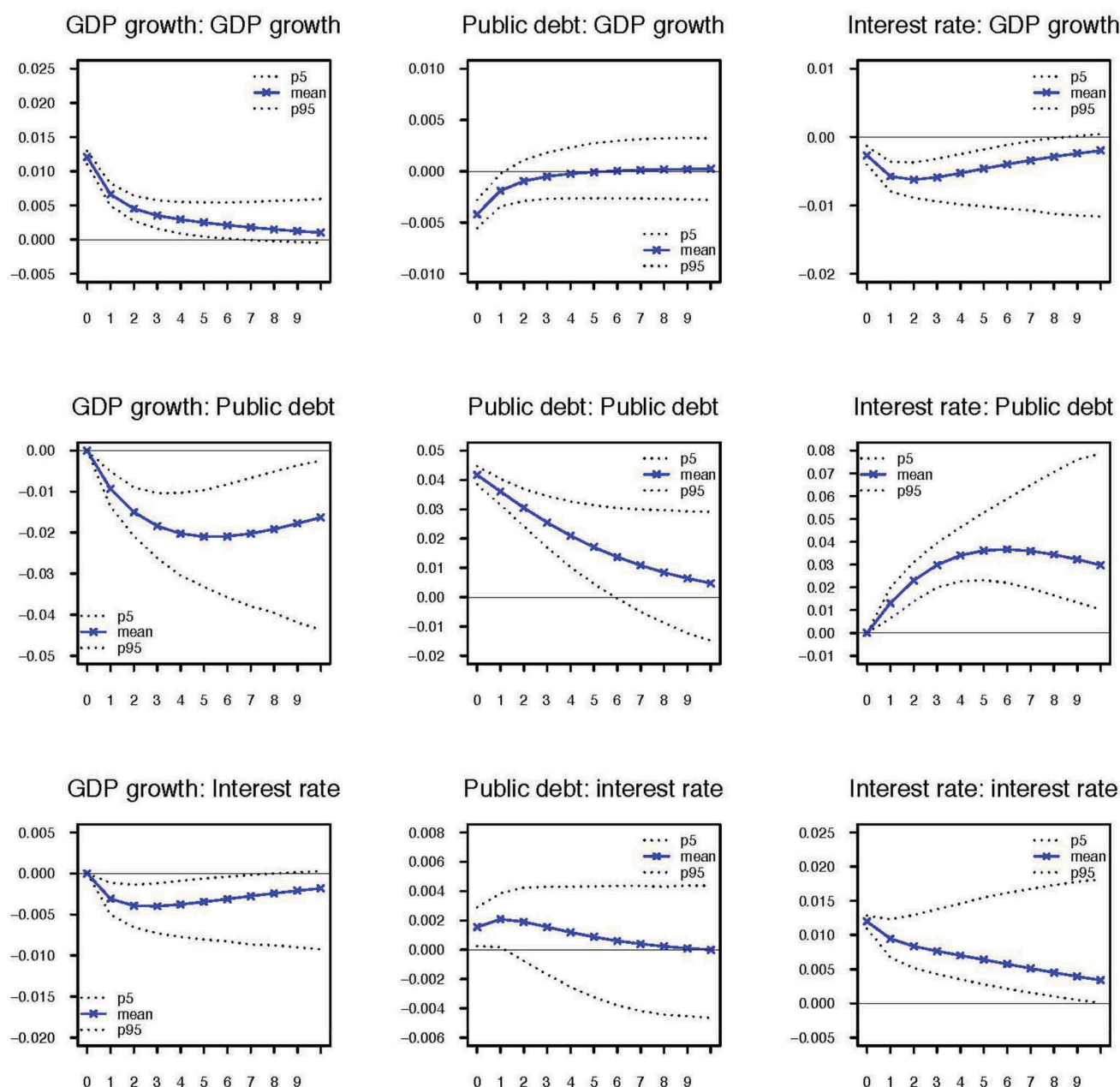


Figure 8. Impulse responses: tri-variate case for high-debt countries.

Notes: impulse variable: response variable

‘unsustainable’, and the long-term real interest rate responds more sensitively to the levels of public debt. In fact, the long-term interest rate in Greece rose sharply during 2011 and 2012 in response to a rise in the debt to GDP ratio. In contrast, the long-term interest rate in

Japan stayed around zero despite soaring government debt.¹⁸

It is important to investigate why the long-term interest rate in one country stays at quite a low level in spite of large public debt, while it sharply rises in another country under the same

¹⁸The correlation coefficient between the nominal interest rate on 10-year government bonds and the debt to GDP ratio during 1995 to 2013 is 0.48 and -0.81 for Greece and Japan, respectively.

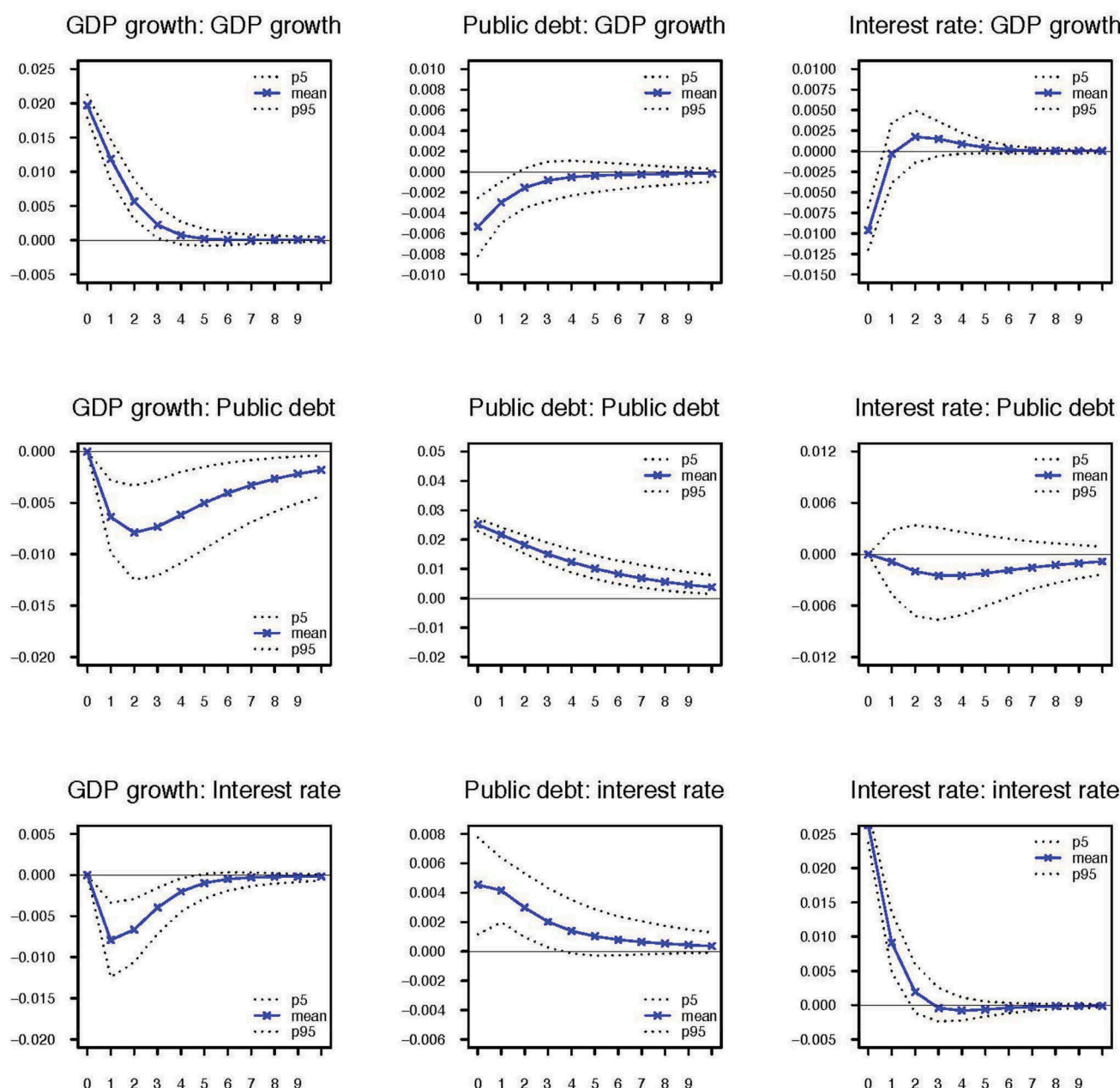


Figure 9. Impulse responses: tri-variate case for low-debt countries.

Notes: impulse variable: response variable

circumstances. This essentially is asking what factors determine a 'sustainable' level of public debt.^{19,20} Solving this problem will provide a

promising platform for designing an economic policy to stabilize economies despite mounting public debt.

¹⁹Many academic researchers warn that the current debt level in Japan is unsustainable. For example, see Dekle (2003), Doi and Ihori (2009), Doi, Hoshi and Okimoto (2011), Ito, Watanabe, and Yabu (2011), Sakuragawa and Hosono (2011) and Hoshi and Ito (2012). Broda and Weinstein (2005) argue that the ratio of government debt to GDP would be stabilized by an increase in tax rates.

²⁰The countries with enormous public debt can still maintain decent economic growth since they possess high growth potentials, such as high productivity. In fact, quite a few countries in the high-public-debt group have attained high Total Factor Productivity growth rates.

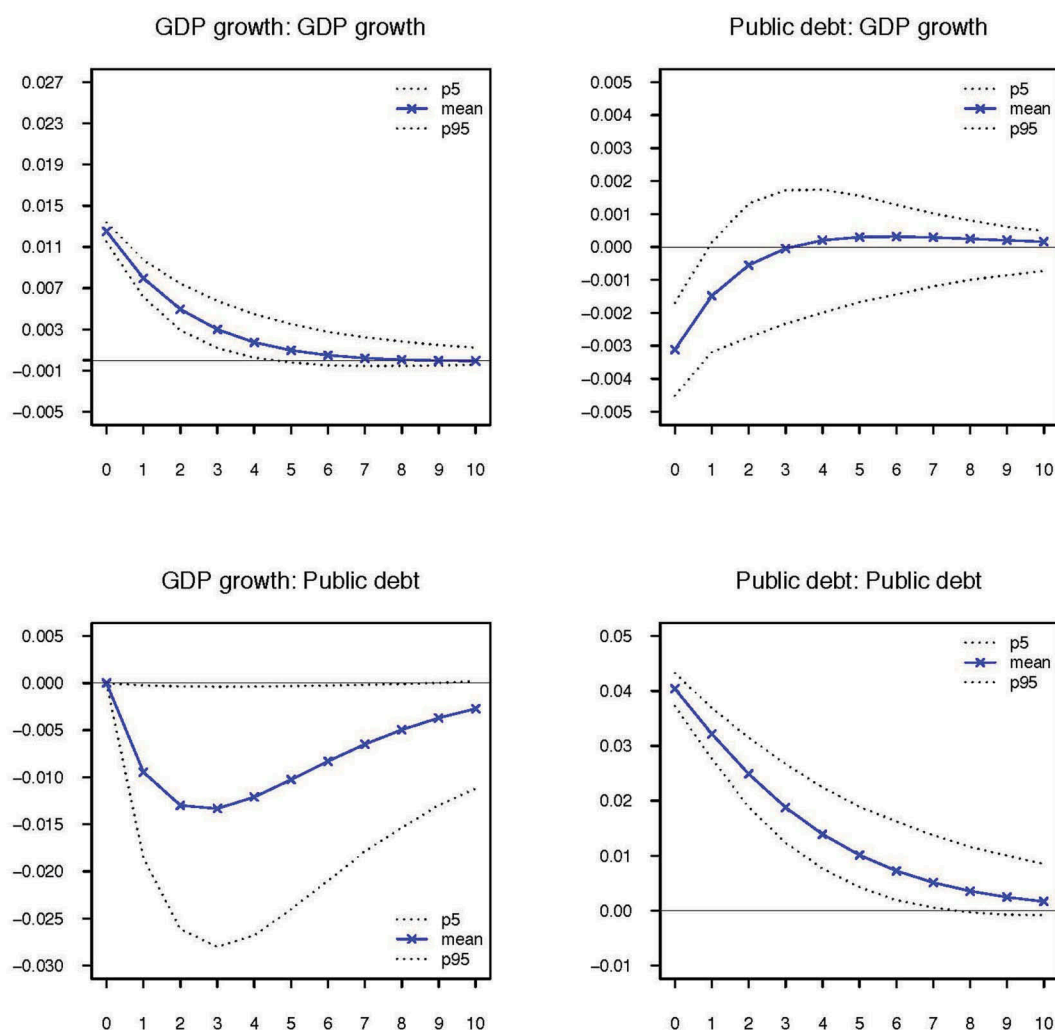


Figure 10. Impulse responses: bi-variate case for high-debt countries with interest rate exogenous.

Notes: impulse variable: response variable

Table 5. Various test statistics of panel VAR model for 11 EMU countries.

	Excluded variables	Granger causality Wald statistics
Bi-variate case	GDP growth equation: Debt-to-GDP ratio	0.108 (0.742)
	Debt-to-GDP ratio equation: GDP growth rate	12.473 (0.000)
Tri-variate case	GDP growth equation: Debt-to-GDP ratio	0.589 (0.443)
	Long-term interest rate	0.296 (0.586)
	Debt-to-GDP ratio equation: GDP growth rate	24.832 (0.000)
	Long-term interest rate	11.279 (0.001)
	Long-term interest rate equation: GDP growth rate	16.386 (0.000)
	Debt-to-GDP interest rate	18.086 (0.000)

Notes: The values in parentheses are *p*-values.

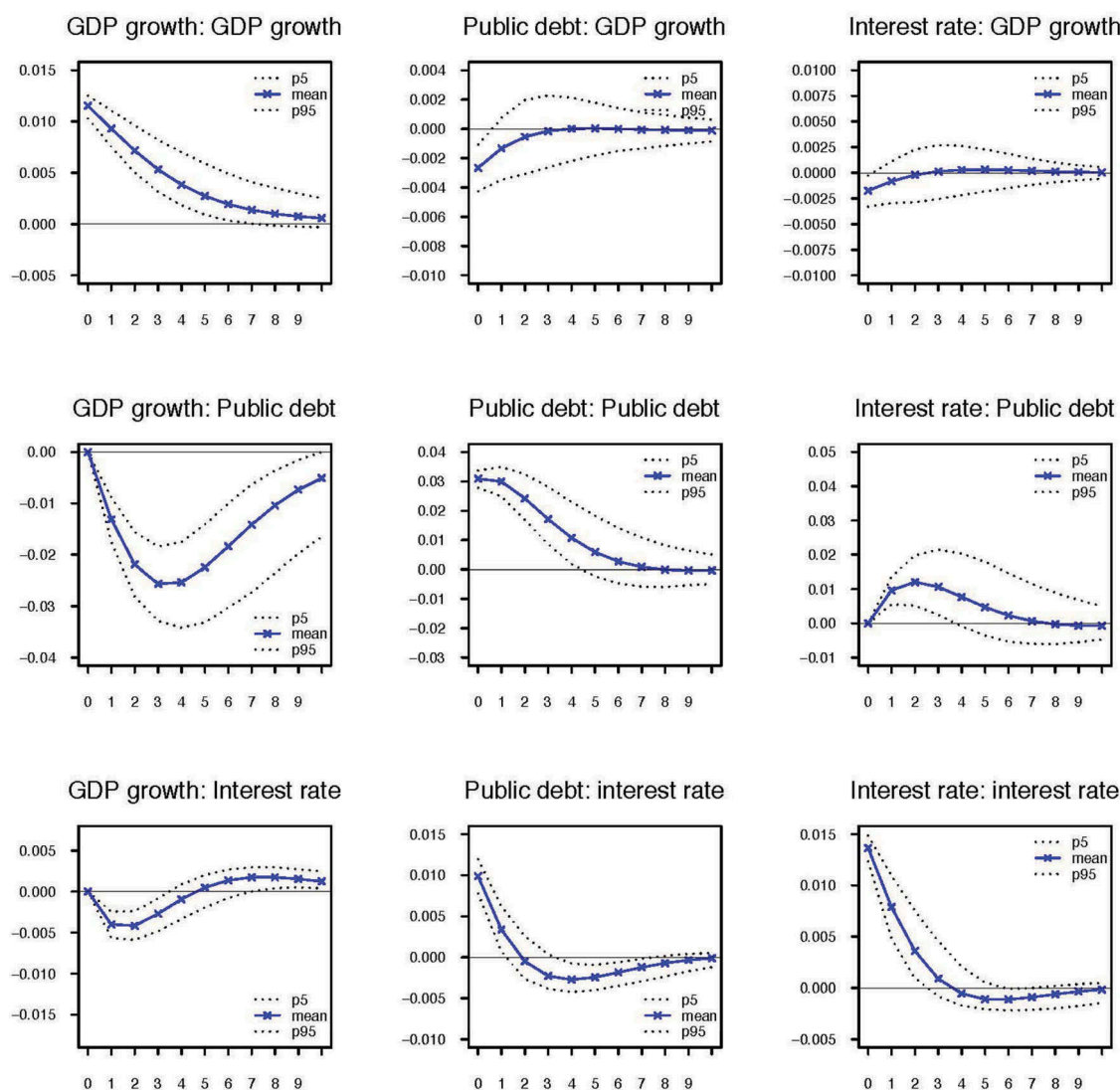


Figure 11. Impulse responses: tri-variate case for 11 EMU countries.
Notes: impulse variable: response variable

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Disclosure statement

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